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SYNOPSIS ON

SYNTHESIS AND CHARACTERIZATION OF Cu DOPED CdS THIN FILMS USING CBD METHOD

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Synthesis and Characterization of Cu doped CdS Thin Films Using CBD Method

1. State of the Art:

II-VI compounds are normally semiconducting material. Both binary and ternary compounds can be developed in this condition. CdSe, CdS, PbS, PbSe, ZnTe, CdTe, CuS, ZnS, CdPbS, CdZnTe, CdZnS, CdMnS, CdAgS, CdCuS, etc are the II-VI compound. Among the above mention compounds CdS is one of them with a bandgap of 2.42 eV at room temperature [1]. The potential applications of CdS are in various areas such as photocatalysis [2], photo detectors [3], spintronics devices [4], solar cells [1], etc. CdS nanocrystalline thin films belonging to the chacogenide family with applications in several heterojunction photovoltaic systems including cadmium telluride (CdTe), copper indium diselenide/sulphide and copper indium gallium diselenide/sulphide (CIGS) solar cells [5,6]. Cu doped CdS semiconducting materials are potential applicable for photo detectors, solar cells, sensor, etc. The energy bandgap of CdS and Cu doped CdS nano films varies from 2.42 eV to 2.31 eV. A number of deposition techniques are being used for the fabrication of Cu doped CdS nanocrystalline thin films e.g., thermal evaporation [7], chemical bath deposition [8], chemical vapour deposition [9], spray pyrolysis [10], molecular beam epitaxy [11], etc. Among the above said methods, chemical bath deposition is an economically simple and commercially scalable technique for the deposition of Cu doped CdS nano films. It has many advantages like it is less hazardous, development of catalyst is free, and deposition layer is uniformly distributed over substrate which can be made possible by carefully handling the process throughout.

It is observed that in the aqueous system there are limitations of temperature, area of the deposits, etc. To avoid the above problems our group has worked on non-aqueous medium for the deposition of Cu doped CdS nano films. Non-aqueous bath for the deposition of metal alloys, semiconductor etc. is expected to solve these problem. In modern technology, structural and optical properties need improvement for more efficient devices.

2. Review of Literature:

A lot of research work has been reported on II-VI semiconductors and their applications in photovoltaic solar cell [12], Light emitters [13], optoelectronics devices, etc. The II-VI semiconducting compounds belonging to the cadmium chalcogenide family is considerable attention due to their potential use in photoconductive devices and solar cells. Solar cells are promising devices to diminished fuel energy consumption, environmental pollution and climate change. Among group II-VI compounds, CdS is one of them. Over the years, priorities were also given on the studies of CdS and Cu doped CdS synthesized by various methods and their effect on the structural, morphological, elemental and optical properties.

(i) Reported works on CdS thin film:

- H.L.Pushpalatha et al. [14] reported the structural properties of CdS nanocrystalline thin films in aqueous medium.
- A Djelloul et al. reported the surface morphology and surface texture of CdS thin films by CBD method.
- Optical properties of CdS thin films synthesized by CBD method in aqueous medium are reported by B.V.Sanap et al. [15]

(ii) Reported works on Cu doped CdS thin films:

- Luis Ixtlilco et al. [16] reported the structural properties of Cu doped CdS nanocrystalline thin films in aqueous medium.
- Richa panda et al. [17] reported the morphological and optical properties of Cu doped CdS thin films in aqueous medium.

3. Problem to be investigated

In the proposed thesis we aim to investigate the following problems:

1. To optimize the conditions for the preparation of CdS and Cu doped CdS thin films using chemical bath deposition technique in non-aqueous medium.

2. To study the physical and optical propertiesof as deposited and annealed copper doped CdS thin films.
3. To optimize the band gap of copper doped CdS thin films through various annealing temperature.

4. To study the effect of copper concentration on physical and optical properties of copper doped CdS thin films.

4. Objectives of the research

- To develop the solubility for precursor of cadmium, sulphur and copper in the alcohol groups bath.
- To grow Cu doped CdS nano films with a chalcopyrite structure with prepared 002 orientations by chemical bath deposition.
- To develop large area Cu doped CdS nano films on ITO glass /FTO glass/Molybdenum substrate.
- To study the structural properties of Cu doped CdS nano films by XRD.
- To measure the average grain size of the deposited films using Scherrer's formula.
- To study the surface morphology, surface features, average grain size, etc using FESEM.
- To study the composition of the deposited films using EDS techniques.
- To study the surface roughness, morphology in two dimensions and three dimensions using AFM technique.
- To study the optical properties of the deposited nano films to determine the bandgap using Tauc's relation.

5. Motivation

Recently, there is a growing interest in II-VI semiconducting materials due to wide range of applications in the field of optoelectronics devices, photovoltaic solar cell, Light emitters, etc. CdS is the member of II-VI compound and has energy bandgap of 2.42 eV.

The energy bandgap shows the light absorption edge and then the visible light spectrum range can be converted into electricity by solar cell.

So, the motivation of the proposed research work will be as follows:

- To develop CdS, Cu:CdS thin films by CBD in non-aqueous medium for optoelectronics devices, photovoltaic solar cells.
- To check the suitability of these developed nano materials as a window material in solar cells.

6. Research Methodology and Tools

(A) Development of material technology

The nano film deposition technique is used for optoelectronic devices, solar cells, sensors, etc. The thin film deposition should be cost effective so that it can be commercially used for device applications. The grains of the deposited film should be spherical well connected to each other, stoichiometric should be maintained and uniform thickness over large area. The optimization of the growth mechanism of the Cu doped CdS nano films along with the following lines:

(i) Optimization of the film deposition in the non-aqueous medium can be carried out by control of molar concentration of different salts, purity and stoichiometry.

(ii) Temperature and stirring is known to influence the nature of the deposition. These will also be optimized suitable substrate materials and it will also be searched for good ohmicity.

(B) Investigation of physical properties of Cu doped CdS Thin films:

(i) **Structural Analysis**-

XRD analysis will be carried out to the Cu doped CdS films to see the hexagonal (002) structure of the film. The average grain size of the films should be calculated by using Debye-Scherrer’s formula.

(ii) **Morphological Studies**-

Field Emission Scanning Electron Microscope (FESEM) will be used to examine the surface feature of the film.

(iii) **Compositional Analysis**-

The composition of Cu doped CdS nano films will be carried out by EDS analysis. The stoichiometry of the films should be maintained by optimizing the molar concentration and annealing condition.

(iv) **Surface roughness**-

The surface roughness of the nano films in two dimensions and three dimensions will be carried out by AFM.

(v) **Optical properties**-

The optical properties of the films will be carried out using UV-Visible spectrophotometer. The band gap of films will be calculated using Tauc's relation.

Tools to be used in collection of data:

The following tools are required in carrying out for our experiments:

(a) Magnetic stirrer with hot plate. It is used for continuously stirrer and heating the electrolyte.

(b) 1200^0c Muffle furnace is used to anneal the samples at desired temperature.

(c) XRD- X-ray diffraction analysis is used to study the structure of the nano films and miller planes of the device. It is also used to calculate the average grain size of the nano films by using Debye-Scherrer's formula.

(d) FESEM- Field emission scanning electron microscope is used to study the surface morphology, distribution of the grains in the films of the deposited nano films.

(e) EDS- Composition of the films can be carried out by Energy dispersive spectrometer. The weight percentage and atomic percentage of individual elements should be calculated.

(f) AFM- Atomic force microscope should be used to study the surface roughness and morphology of the nano films in two dimensions and three dimensions.

Prospective Collaborations:

(i) National Institute of Foundry and Forge Technology, Hatia, Ranchi

(ii) Indian Institute of Technology (Indian School of Mines), Dhanbad

(iii) Indian Institute of Technology, Kharagpur

(iv) Indian Institute of Technology, Patna

(v) National Metallurgical Laboratory, Jamshedpur

(vi) Central University of Jharkhand (Dept. of Nanotechnology), Ranchi

7. Significance of proposed work

The said work will be used to develop Cu doped CdS nano films for optoelectronic devices, solar cells and sensors. It is observed that if the device gives more than 15% conversion efficiency it can be easily commercialized.

8. Future prospect

- In the present day due to the crisis of the fuel, oil, coal, etc people are switching over the non-conventional energy sources. In this category photovoltaic solar cell is versatile for converting solar energy to electricity.
- Non-aqueous deposited CdS/Cu: CdS films will be applicable for optoelectronics devices, photovoltaic solar cells.
- Cu_2S may be deposited over CdS films to form the solar cell devices.

9. Limitations

- Required deposition temperature for Cu doped CdS thin films prepared in non-aqueous medium should not exceed 180^0c.
- After introducing of Cu on CdS bath, required crystallite size of the said films should increase.
- Need of annealing temperature of the said films should not exceed beyond 700^0c.

10. Tentative Chapterization:

Chapter 1: Introduction and Literature Review

- This chapter will give general information about semiconductor, concept of thin film and brief description of photovoltaic solar cells.
- This chapter will consists of different steps involved in the deposition process along with basic principle of chemical bath deposition technique.

Chapter 2: Characterization Techniques:

This chapter will gives a brief account of characterization of thin films prepared by chemical bath deposition (CBD) by different instruments:

- X-ray diffraction (XRD) will give information about structure of the proposed thin films.
- Surface morphology and elemental analysis of the deposited films will be carried out by Field emission scanning electron microscope.
- Surface roughness of the deposited films will be carried out by Atomic force microscope.
- Optical characterization will be carried out by UV-VIS Spectrophotometer.

Chapter 3: Deposition and characterization of CdS thin films:

In this chapter, the structural, morphological, compositional and optical properties of CdS as deposited and annealed thin films will be discussed.

Chapter 4: Deposition and characterization of Cu doped CdS thin films:

In this chapter, the physical and optical properties of Cu doped CdS as deposited and annealed thin films will be studied.

Chapter 5: Optimization of band gap of Cu doped CdS thin films through various annealing temperature.

In this chapter, the band gap and other optical properties of Cu doped CdS thin films will be investigated by annealing at various temperatures.

Chapter 6: Effect of varying Cu concentration on Cu: CdS thin films:

In this chapter, the properties of as deposited and annealed Cu doped CdS thin films will be studied for varying concentration of Cu (0%, 1%, 2% and 3%).

Chapter 7: Summary and Conclusions:

In this chapter, summary of the results and conclusions based on the proposed work along with future scope of the proposed studies will be discussed.

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